The Making, Shaping and Treating of Steel

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removed. Other atmosphere gases are prepared by (1) cracking a non-combustible mixture of air and gas with a catalyst at high temperature, (2) by cracking anhydrous ammonia at high temperature, and (3) by passing air through a heated retort filled with charcoal.

Furnaces using controlled atmosphere have a number of construction features not incorporated in ordinary furnaces. These features are essential to prevent loss of gas and to minimize the entrance of air into the furnace which would upset the control established. Casings for furnaces with controlled atmosphere are welded gas-tight. Batch-type furnaces are provided with sand seals. Continuous furnaces charged and discharged from the ends sometimes have flame curtains to burn out the oxygen from any possible air infiltration, or the furnace may be operated under sufficient pressure to prevent air infiltration. In the latter case, a small loss of the prepared atmosphere usually occurs through the small unavoidable openings in the furnace. Doors, where required, are fitted snugly by sloping fronts with ground surfaces or by wedging devices or clamps. Modern continuous pusher-type furnaces for special heat treatment of bar and wire coils utilize a vestibule and inner-door arrangement at the charge and discharge ends of the furnace. This permits complete purging of air as material is charged and discharged from the furnace

Batch-Type Furnaces—The five principal general types of batch furnaces are described below:

1. **Box furnaces** are constructed with a solid hearth. They are shaped, as their name implies, similar to a box and are charged through door openings by tongs or some mechanical charger. The furnace hearth may vary from less than half a square metre to nearly 3 square metres (a few square feet to over 30 square feet). Heating may be done by direct or indirect fuel firing or by electricity. Muffle and semi-muffle type construction often is employed when control of atmosphere is required. This type of furnace is used frequently for individual-piece or small-lot heat treating, for laboratory test and shop work, and for general production work on a small scale. Box furnaces have been constructed for convection heating either with a fan underneath the roof or with one external to the furnace for recirculation. Furnaces of this type are used for annealing, normalizing, tempering and carburizing.

2. **The car-bottom furnace** consists of a furnace shell equipped with burners or heating units with the hearth built upon a separate car which runs in and out of the furnace shell to charge and unload the furnace. The car usually is moved into and out of the furnace by a toothed rack attached to the bottom of the car and a stationary pinion actuated by an electric motor, the car itself resting on rollers or wheels that move over a two-rail track. The doors of the furnace are of the vertically lifting type, full width of the furnace, and are hydraulically or electrically operated. In order that the entire surface of the charge may be exposed to heat of the same intensity and to aid circulation, the charge is supported above the floor of the car bottom by heat-resisting alloy castings or on refractory piers. The car bottom is made to fit the furnace closely and the escape of hot gases around it is prevented by sand seals. Car-bottom furnaces have been constructed to process charges from a few tons to several hundred tons. They are used for heat treating of axles, bars, heavy plates, castings and miscellaneous shapes.

For operations involving heating, quenching and tempering, it is desirable that the quenching tank be located in close proximity to the furnace to enable the charge to be placed in the tank in the shortest possible time. In some installations, less than a minute is required to transfer the charge from a closed furnace to the quenching tank.

Car-bottom furnaces may be direct or indirect fired, and various designs have been developed to improve heat distribution in the working chamber. Electric heating also is employed in some car-bottom furnaces. Car-bottom furnaces sometimes are constructed of two chambers side by side, with a common division wall to facilitate annealing and tempering operations. In some installations, an auxiliary cooling system employing blowers is provided to accelerate cooling. Some car-bottom furnaces are known as **elevator furnaces** where the car is rolled under the furnace shell and then raised into the furnace by a motor-driven lifting mechanism. Those in which the shell is lowered over the car, as shown in Figure 41—51, are used to provide a more complete sand or water seal than is obtainable with the conventional car-bottom furnaces.

3. **The bell-type furnace** has a removable shell or cover. The furnace usually is used for processing material which requires special surface protection from oxidation or decarburization. The furnace shell is removed by a crane and set aside while the hearth of the furnace is charged. The shell is then replaced, as was shown in Figure 41—49. Furnaces of this type, used for annealing sheet, strip, rod and wire, usually are called **box annealing, pack annealing, coil annealing, or cover annealing furnaces.** In these, the material is stacked on a permanent base or **stand, a light inner cover** is placed over the stack, sealed with sand at the bottom and provided with a constant supply of prepared gas atmosphere, and then the portable heating unit is lowered over the assembly. The heating covers are square, rectangular or cylindrically shaped. Loads vary from about 32 to 363 metric tons (35 to 400 net tons) per charge, distributed on one to eight stands per base. In most instances, a number of bases and inner covers are provided with one or more covers for heating. After heating of each charge is completed on a base, the heating cover is moved to another base, leaving the charge protected by the atmosphere under the inner cover which is left in place. The covers may be direct fired or equipped with radiant tubes for indirect firing, or they may be heated by electrical resistance units. The heating elements are attached to the inside of the heating cover, which is built of steel and lined with a refractory insulating material and braced substantially in order that it can be moved from base to base with an overhead crane. Many inner covers are made of heat-resisting alloys. All are sealed to the base at their bottom edges with a powdered refractory. The heating time in a cover annealing furnace for coils of sheet or tin plate range from 24 to 44 hours for the larger sized furnaces, depending upon the length of soaking period required. The soaking period usually is about 4 to 12 hours. In furnaces of about 135 to 270

metric tons (150 to 300 net tons) capacity, the average production is about 5 metric tons (5.5 net tons) per hour, the fuel consumption about 1 163 000 kilojoules per metric ton (1 000 000 Btu per net ton), the maximum fuel-burning capacity about 3 517 000 watts (12 000 000 Btu per hour), and the atmosphere-gas consumption about 34 cubic metres (1200 cubic feet) per hour. In pack or box annealing furnaces, natural gas or some inert gas is used to surround the charge; the circulation of gases inside the inner cover is by natural or forced convection. In cover furnaces for annealing coils, separators are placed between each coil to aid in distribution of the gas inside the inner cover. Circulation of this gas in a number of modern installations is forced. The fan is located in the base below each stand. The trend in annealing sheet and tin plate has been towards the greater use of coils and heating by forced convection rather than by the former pack method of annealing, in order to obtain higher production and improved uniformity of heating.

4. **Pit furnaces** are furnaces of cylindrical or rectangular shape in which the material is charged and withdrawn through an opening in the furnace top. The larger furnaces are installed usually with at least part of their work chambers below floor level, while many of the smaller and shallower furnaces rest on the working floor, for convenience in handling material. The material to be processed can be suspended by a fixture, loaded into a basket and set into the working chamber, or, as in the case of large forgings, be supported on a suitable base in the furnace. Pit furnaces employ either direct firing or electrical heating, in either case with natural or forced circulation. They may or may not be equipped with special facilities for atmosphere control. Pit furnaces are used for normalizing, hardening, annealing, tempering, and carburizing.

5. **A salt-bath or lead-bath furnace** is another type of heat-treating furnace. It is designed to hold a bath of molten salt or lead in which the material is immersed for treatment. These furnaces are usually small pot-like affairs used in batch operations, but some large furnaces have been constructed of rectangular shape with depths of over 4.5 metres (15 feet) to suit the shape and size of the material to be handled, with conveyors or other means for carrying out continuous operations. They are equipped usually with a hinged cover or a ventilating hood for minimizing fumes. Such furnaces are used to obtain uniform temperature distribution and close temperature control of the work piece. The bath is heated and maintained at proper temperature either by electrical resistance or by combustion of a fuel. Furnaces with a molten bath for heat treating are called **pot furnaces** when the bath is contained in a pot or crucible constructed of a heat- and corrosion-resistant metal, usually externally heated by suitable burners. Other bath-type furnaces may be heated by electric current passing through the (salt) bath between immersed electrodes, or by immersed resistance coils or fuel-fired tubes.

Continuous Furnaces—In continuous furnaces, the

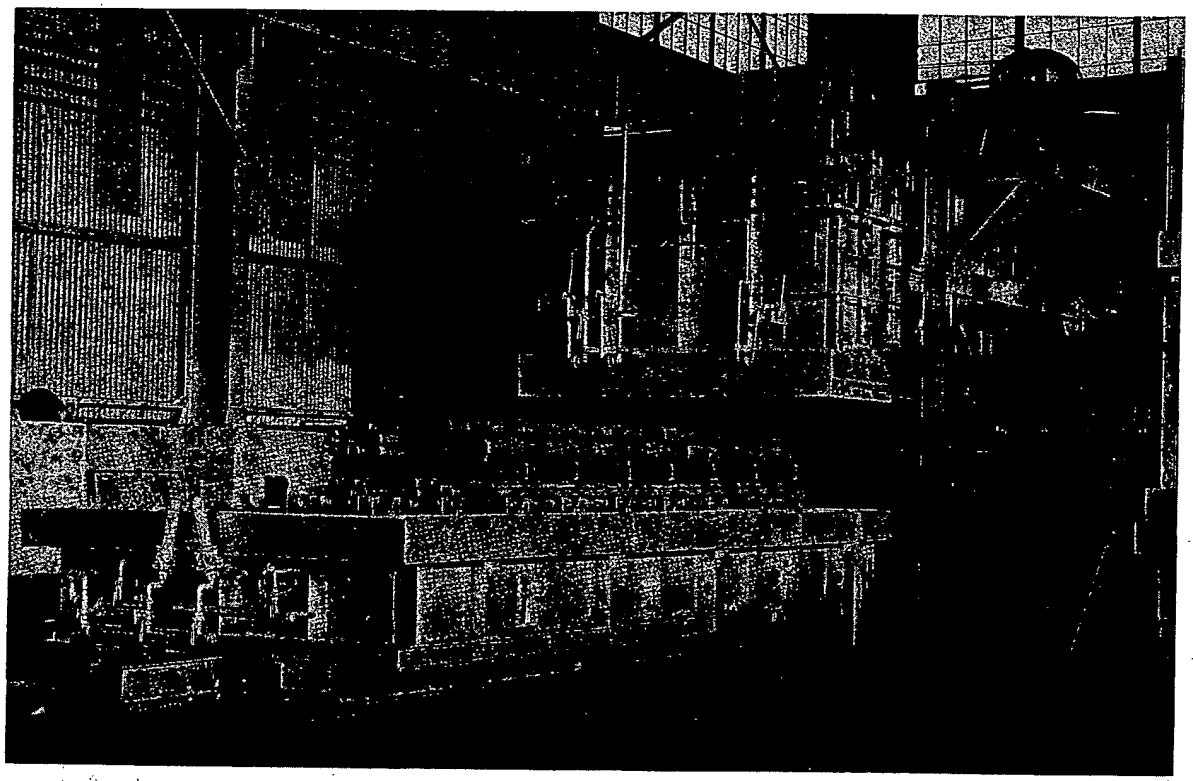

FIG. 41—51. Charge of mixed sizes of steel bars, supported above hearth by cast-alloy fixtures, ready to be rolled under bell-type furnace body, which then will be lowered over charge. Toothed rack above floor at lower left is driven by a pinion to move car. (Courtesy, Surface Combustion Div., Midland-Ross Corp.)